

**"EXPRESS MAIL" MAILING LABEL NUMBER
EU516996635US**

I HEREBY CERTIFY THAT THIS PAPER OR FEE IS BEING DEPOSITED WITH THE U.S. POSTAL SERVICE "EXPRESS MAIL POST OFFICE - TO - ADDRESSEE" SERVICE UNDER 37 CFR 1.10 OR THE DATE INDICATED BELOW AND IS ADDRESSED TO THE COMMISSIONER FOR PATENTS, P.O. BOX 1450, ALEXANDRIA, VA 22313-1450, ON

October 24, 2003 DATE OF DEPOSIT
Lisa D. Jones
SIGNATURE OF PERSON MAILING PAPER OR FEE
LISA D. JONES
NAME OF PERSON SIGNING
10-24-03
DATE OF SIGNATURE

**METHOD AND APPARATUS FOR
SELF-DIAGNOSTICS OF A VISION SYSTEM**

Technical Field

The present invention is directed to a vision system for recognizing an object and determining a location of the object in an area of interest. More particularly, the present invention is directed to a method and apparatus for self-diagnostics of a vision system in a vehicle occupant protection system of a vehicle.

Background of the Invention

Vehicle occupant protection systems typically includes an inflatable device, such as an air bag, that is inflatable for helping to protect an occupant of a vehicle. Some vehicle occupant protection systems control the inflatable device in response to occupancy of the seat, a determination of whether an object on

the seat is animate or inanimate, a determination that a rearward facing child seat is present on the seat, and/or a determination of an occupant's position, weight, size, etc. An exemplary vehicle occupant protection system is disclosed in U.S. Patent No. 5,330,226.

Some vehicle occupant protection systems use cameras to determine the location of the occupant in the passenger compartment of the vehicle. Inflation of the inflatable device is controlled in response to the determined occupant location. At times, the view of the cameras into the passenger compartment may become obstructed. For example, if the occupant is reading a newspaper, the view of the cameras into the passenger compartment may be obstructed. Excessive dirt or other substances on a housing for the cameras may also obstruct the view of the cameras into the passenger compartment. Additionally, changes in temperatures, vibrations, and other factors that are frequently experienced by vehicles may cause the cameras to come out of calibration. When the cameras come out of calibration, the determined location of the passenger may be erroneous. Thus, it is desirable to prevent an erroneous determination of the location of the occupant

in response to the view of the cameras becoming obstructed or the cameras coming out of calibration.

Summary of the Invention

The present invention relates to an apparatus for
5 determining a location of an object in an area of
interest. The apparatus comprises an imaging device
for obtaining an image of the area of interest. At
least three identifying marks are located at
predetermined positions in the area of interest. The
10 apparatus also comprises a memory in which the
predetermined positions of the at least three
identifying marks are stored. A controller determines
whether the imaging device is calibrated properly by
analyzing the image obtained by the imaging device to
15 determine whether positions of the at least three
identifying marks in the obtained image correspond to
the predetermined positions stored in the memory. The
controller determines the location of the object in the
area of interest when the imaging device is calibrated
20 properly.

In accordance with another aspect, the present
invention relates to a method of self-diagnostics of an
apparatus for determining a location of an object in an
area of interest. The method comprises the steps of

obtaining an image of the area of interest using an imaging device; locating at least three identifying marks at predetermined positions in the area of interest; storing in a memory the predetermined positions of the at least three identifying marks; 5 determining whether the imaging device is calibrated properly by analyzing the obtained image to determine whether positions of the at least three identifying marks in the obtained image correspond to the 10 predetermined positions stored in the memory; and determining a location of the object in the area of interest when the imaging device is calibrated properly.

In accordance with a further aspect, the present 15 invention relates to an apparatus for determining a location of an object in an area of interest. The apparatus comprises an imaging device for obtaining an image of the area of interest. A controller analyzes a feature of the obtained image to determine whether a 20 view of the area of interest from the imaging device is obstructed. The apparatus also comprises an indicator that is actuatable for indicating to the object that the view is obstructed. The controller controls actuation of the indicator. The controller

analyzes the obtained image to determine the location of the object when the view is unobstructed.

In accordance with yet another aspect, the present invention relates to a method of self-diagnostics of an apparatus for determining a location of an object in an area of interest. The method comprises the steps of obtaining an image of the area of interest with an imaging device; analyzing a feature of the obtained image to determine whether a view of the area of interest from the imaging device is obstructed; providing an indication to the object when the view is obstructed; and analyzing the obtained image to determine the location of the object when the view is unobstructed.

Brief Description of the Drawings

The foregoing and other features and advantages of the present invention will become apparent to those skilled in the art to which the present invention relates upon reading the following description with reference to the accompanying drawings, in which:

Fig. 1 is a schematic illustration of a vehicle occupant protection system constructed in accordance with an exemplary embodiment of the present invention and associated with a seat of a vehicle;

Fig. 2 is a schematic illustration of a stereo-vision assembly of the vehicle occupant protection system of Fig. 1;

Fig. 3 is a perspective view of an empty passenger seat and a portion of the vehicle including identifying marks of the vehicle occupant protection system of the present invention;

Fig. 4 is flow diagram illustrating a control process in accordance with an exemplary embodiment of the present invention;

Fig. 5 is a flow diagram illustrating a calibration algorithm in accordance with an exemplary embodiment of the present invention; and

Fig. 6 is a schematic illustration of a blob from an image obtained by the vehicle occupant protection system of the present invention.

Description of Preferred Embodiment

Fig. 1 is a schematic illustration of a vehicle occupant protection system 20 in accordance with exemplary embodiment of the present invention. The vehicle occupant protection system 20 includes an air bag assembly 22 that is mounted in an opening of an instrument panel 24 of a vehicle 26. The air bag assembly 22 includes an air bag 28. Fig. 1 illustrates

the air bag 28 in a deflated and folded condition stored within an air bag housing 30. The air bag 28 is adapted to inflate in response to receiving inflation fluid. During inflation, the air bag 28 expands through the opening in the instrument panel 24 and into a passenger compartment 31 of the vehicle 26. A cover 32 covers the stored air bag 28 and closes the opening in the instrument panel 24. The cover 32 is adapted to open during inflation of the air bag 28.

The air bag assembly 22 further includes an inflation gas control portion 34 that is operatively coupled to the air bag 28. The inflation gas control portion 34 may include a plurality of inflation fluid sources (not shown) and vent valves (not shown) for controlling inflation of the air bag. For example, the inflation gas control portion 34 may control the timing of inflation, the flow of inflation gas during inflation, the bag profile as a function of time, and the inflation gas pressure. The air bag 28, when inflated into the passenger compartment 31 of the vehicle 26, helps to protect an occupant 40 that is seated on a vehicle seat 42 associated with the vehicle occupant protection system 20.

The vehicle seat 42 illustrated in Figs. 1 and 3 is a passenger seat of the vehicle 26. Although the vehicle occupant protection system 20 is described as being associated with the passenger seat 42 of the vehicle 26, the vehicle occupant protection system 20 may alternatively, or additionally, be associated with other seats of the vehicle 26. The vehicle occupant protection system 20 may also control actuation of other vehicle occupant protection devices, such as side air bags.

An air bag controller 50 is operatively connected to the air bag assembly 22 to control the inflation gas control portion 34 and, in turn, control the inflation of the air bag 28. The air bag controller 50 can take any of several forms such as a microcomputer, discrete circuitry, an application-specific-integrated-circuit ("ASIC"), etc. The air bag controller 50 is further connected to a vehicle crash sensor 52, such as one or more vehicle crash accelerometers. The air bag controller 50 receives output signals from the crash sensor 52 and, in accordance with a control algorithm, determines if a deployment crash event is occurring. A deployment crash event is a crash event in which it is desirable to inflate the air bag 28. There are several

known control algorithms that may be used for determining whether a deployment crash event is occurring. Once the air bag controller 50 determines that a deployment crash event is occurring, the air bag controller 50 is responsive to signals indicating a location of the occupant 40 for controlling inflation of the air bag 28 using the inflation gas control portion 34 of the air bag assembly 22.

The vehicle occupant protection system 20 further includes a stereo-vision assembly 60. The stereo-vision assembly 60 includes an imaging device 61 that is located a housing 62. The housing 62 is preferably mounted to the headliner 64 of the vehicle 26. The imaging device 61 includes two cameras 70 and 72 and an illuminator 74. Fig. 1 illustrates the cameras 70 and 72 and the illuminator 74 located in the housing 62.

Alternatively, the illuminator 74 may be mounted on the instrument panel 24 of the vehicle 26. In accordance with one exemplary embodiment of the present invention, the cameras 70 and 72 are spaced apart from one another by approximately 35 millimeters, although other spacing may be used. The cameras 70 and 72 are positioned in

parallel with the front-to-rear axis of the vehicle, although other orientations are possible.

Each of the cameras 70 and 72 includes a shutter (not shown) that has a variable speed. The variable speed shutters enable exposure times of the cameras 70 and 72 to be varied. When the light intensity is low, the exposure time is lengthened and the shutters remain open for longer periods of time. When the light intensity is high, the exposure time is shortened and the shutter is opened for shorter periods of time.

The illuminator 74 illuminates the passenger compartment 31 of the vehicle 26 to enable the cameras 70 and 72 to obtain images during low ambient light conditions. The illuminator 74 provides a light that is outside of the visible range for the occupant 40 of the vehicle 26. In an exemplary embodiment, the illuminator 74 is a near-infrared light source.

A camera controller 80 is operatively connected to the cameras 70 and 72 and the illuminator 74. The camera controller 80 can take any of several forms such as a microcomputer, discrete circuitry, ASIC, etc. The camera controller 80 controls the illuminator 74 and the cameras 70 and 72. The camera controller 80 is

also connected to the air bag controller 50 and provides signals to the air bag controller 50 indicating the location of the occupant 40 relative to the cover 32 of the air bag assembly 22.

5 The stereo-vision system 60 also includes a nonvolatile memory 78. The memory 78 may form a portion of the camera controller 80 or may be separate from the camera controller. In Fig. 1, the memory 78 is separate from the camera controller 80 and is
10 operatively connected to the camera controller.

 The vehicle occupant protection system 20 also includes a vision system error indicator 82. The vision system error indicator 82 is operatively connected to the air bag controller 50 and is
15 actuatable for indicating to the occupant 40 that a vision system error has occurred. The air bag controller 50 is responsive to an error indication signal from the camera controller 80 for actuating the
20 vision system error indicator 82. The vision system error indicator 82 may provide any one or more of an audio, visual, or tactile signal to the occupant 40 of the vehicle 26.

 Fig. 2 is a schematic illustration of the cameras 70 and 72 of the imaging device 61. The

cameras 70 and 72 may be of any several known types.

For example, the cameras may be charge-coupled devices ("CCD") or complementary metal-oxide semiconductor ("CMOS") devices. Preferably, the cameras 70 and 72

5 take two-dimensional, grayscale images of the passenger compartment 31 of the vehicle 26. In one exemplary embodiment of the present invention, the cameras 70 and 72 are wide spectrum response cameras that cover the visible and near-infrared spectrums.

10 The cameras 70 and 72 are spaced apart from one another so as to enable the cameras to be used for determining a distance, also called a "range," from the cameras to an object. The object is shown schematically in Fig. 2 and is indicated by reference
15 numeral 94. The distance between the cameras 70 and 72 and the object 94 may be determined by using triangulation. The cameras 70 and 72 have different views of the passenger compartment 31 due to the position of the object 94 relative to each camera 70
20 and 72 being different. As a result, the object 94 is located at a different position in the image obtained by camera 70 than in the image obtained by camera 72. The difference in the positions of the object 94 in the images is referred to as "disparity." To get a proper

disparity between the images for performing triangulation, it is desirable for the cameras 70 and 72 to be positioned so that the object 94 to be monitored is within the horopter of the cameras.

5 Camera 70 includes a lens 100 and a pixel array 110. Likewise, camera 72 includes a lens 102 and a pixel array 112. Since the cameras 70 and 72 are located at different positions relative to the object 94, an image of the object 94 formed on the pixel array 110 of camera 70 differs from an image of the object 94 formed on the pixel array 112 of camera 72. The distance between the viewpoints of the cameras 70 and 72, i.e., the distance between the lenses 100 and 102, is designated "b" in Fig. 2. The focal length of the lenses 100 and 102 of the cameras 70 and 72 is designated as "f" in Fig. 2. The lenses 100 and 102 of the cameras 70 and 72 of Fig. 2 have the same focal lengths. The horizontal distance from the image center on the pixel array 110 and the image of the object 94 on the pixel array 110 of camera 70 is designated "dl" in Fig. 2. The horizontal distance from the image center on the pixel array 112 and the image of the object 94 on the pixel array 112 for the camera 72 is designated "dr" in Fig. 2.

Preferably, the cameras 70 and 72 are mounted so that they are in the same image plane. The difference between d_l and d_r is referred to as the "image disparity" and is directly related to the distance, designated "r" in Fig. 2, to the object 94 where the distance r is measured normal to the image plane of cameras 70 and 72 from a location v on the image plane. It will be appreciated that

$$r = bf / d, \text{ where } d = d_l - d_r. \quad (\text{Equation 1})$$

From equation 1, the distance r to the object 94 as a function of disparity of the images from cameras 70 and 72 can be determined. It should be appreciated that the distance r is an inverse function of disparity.

Fig. 3 is a perspective view of the seat 42 in an unoccupied condition. Fig. 3 also illustrates portions of the interior vehicle structure. The interior vehicle structure includes interior trim 84 for covering the B-pillar of the vehicle 26. The interior vehicle structure also includes an interior door panel 86 having an upper surface 88 and an armrest portion 90.

Fig. 3 also illustrates three identifying marks 104 that are located on the interior vehicle

structure and are viewable to the cameras 70 and 72 of the imaging device 61. One of the three identifying marks 104 in Fig. 3 is located on the interior trim 84 that covers the B-pillar. The other two identifying marks 104 are located on the upper surface 88 and on the armrest portion 90 of the interior door panel 86, respectively. The three identifying marks 104 may have other locations on the interior vehicle structure than those illustrated in Fig. 3.

10 The identifying marks 104 may be formed from a near-infrared dye so as to be invisible to the occupant 40 of the vehicle 26. When the identifying marks 104 are formed from a near-infrared dye, the cameras 70 and 72 are near-infrared cameras configured to obtain images in which the identifying marks are visible. The identifying marks may alternatively be in the visible or infrared spectrum with appropriate type imagers for obtaining the images that include the identifying marks. Alternatively, the three
15 identifying marks 104 may be formed from portions of the interior vehicle structure that have fixed positions relative to a location, indicated schematically in Fig. 2 as v, of the imaging device 61. The portions of the interior vehicle structure that
20

form the identifying marks must be visible in the images taken by the cameras 70 and 72, particularly, when the seat 42 is in the unoccupied condition.

5 The three identifying marks 104 are positioned in the vehicle so as to be non-collinear from the viewpoint of the cameras 70 and 72. For example, assuming that the view in Fig. 3 is representative of the views from cameras 70 and 72, the locations of the identifying marks 104 do not fall into a straight line.
10 When the three identifying marks 104 are non-collinear, as viewed by the cameras 70 and 72, a plane containing the three identifying marks 104 may be calculated from the locations of the three identifying marks. If, for example, the three identifying marks 104 were
15 collinear, then multiple planes exist that contain the three identifying marks 104.

 A plane can be calculated from three non-collinear points, such as points P_1 , P_2 , and P_3 . To calculate the plane two vectors, e.g., $(P_2 - P_1)$ and $(P_3 - P_1)$, are
20 determined. A normal N to the plane is computed by taking the cross product of the two vectors,
$$N = (P_2 - P_1) \times (P_3 - P_1).$$
 The equation for the plane is determined from the calculated normal N and one of the

points in the plane, e.g., P_1 . Thus, the equation for the plane is NP_1 .

The exact three-dimensional location of each of the three identifying marks 104 relative to the location v of the stereo-vision system 60 is predetermined and is stored in the memory 78 of the camera controller 80. Also stored in the memory 78 is an equation defining a predetermined plane that includes the three identifying marks 104.

The three identifying marks 104 are used to determine whether the imaging device 61 of the stereo-vision assembly 60 is calibrated properly. The cameras 70 and 72 each take an image of the passenger compartment 31 of the vehicle 26. A pattern recognition algorithm, such as is performed by a neural network, a support vector machine, or another statistical type of classification algorithm analyzes the images obtained by the cameras 70 and 72 for the identifying marks 104. When all three identifying marks 104 are recognized, the camera controller 80 determines a three-dimensional location of each of the identifying marks 104 relative to the location v of the imaging device 61 using the disparity of the images. The locations of the identifying marks 104 from the

images is compared to the predetermined locations of the identifying marks 104 that are stored in the memory 78. When the locations of the identifying marks 104 in the images correspond to the predetermined locations of the identifying marks 104, the imaging device 61 is determined to be calibrated properly.

In an exemplary embodiment of the present invention, the camera controller 80 calculates an identifying plane that includes the three identifying marks 104 of the images from cameras 70 and 72. The identifying plane is compared to the predetermined plane that is stored in the memory 78. When the identifying plane and the predetermined plane are identical, the imaging device 61 is determined to be calibrated properly. When the identifying plane is distorted or shifted relative to the predetermined plane, the imaging device 61 is determined to be out of calibration.

Referring to Fig. 4, a control process 400, in accordance with an exemplary embodiment of the present invention, is shown. The process 400 is initialized in step 402 in which internal memories are set to initial conditions, initial flag conditions are set, etc. The initialization at step 402 preferably occurs each time

the vehicle ignition (not shown) is started. In
step 404, board level diagnostics and hardware
diagnostics of the equipment of the stereo-vision
assembly 60 is performed. Various board level and
5 hardware diagnostic algorithms are known and may be
used at step 404. At step 406, each camera 70 and 72
of the imaging device 61 obtains an image of the
passenger compartment 31 of the vehicle 26. The images
taken at step 406 include an image of an object, such
10 as occupant 40, located in the seat 42. The
process 400 proceeds from step 406 to step 408.

At step 408, a determination is made as to whether
the exposure of the images obtained at step 406 is
between low and high exposure thresholds, i.e., in an
15 exposure range. The exposure is the average intensity
from the grayscale image multiplied by the exposure
time. The average intensity from the grayscale image
is the average pixel value of the pixels in the
respective pixel arrays 110 and 112. For example, in
20 an 8-bit image, a pixel value of each pixel is in the
range of zero, which is indicative of black, to 255,
which is indicative of white. Pixel values between
zero and 255 are indicative of shades of gray with
lower pixel values being darker and higher pixel values

being lighter. The average pixel value is the average value of all of the pixels in the respective pixel array 110 and 112. The exposure time is the time that the shutter of each of the cameras 70 and 72 is open.

5 Preferably, the exposure of each image is determined and is compared to the low and high exposure thresholds at step 408. Since the cameras 70 and 72 are located in close proximity to one another, the exposure of only one of the cameras 70 and 72 may be determined and
10 compared to the low and high exposure thresholds at step 408.

When the determination at step 408 is negative and the exposure of the images is not between the low and high exposure thresholds, i.e., is outside of the
15 exposure range, the process 400 proceeds to step 412 and an error indication is provided. From step 412, the process 400 returns to step 406. When the determination at step 408 is negative, it is highly probable that the view of the passenger compartment 31
20 from one or both of the cameras 70 and 72 of the imaging device 61 is obstructed. When the determination at step 408 is affirmative and the exposure is between the low and high exposure thresholds, the process 400 proceeds to step 414.

At step 414, a distance calculation takes place to determine the distance r to the object in the images. The distance calculation uses equation 1, above, to determine the distance r . Since the cameras 70 and 72
5 view the seat 42, the object of the images will be either the seat 42 itself or an object interposed between the cameras 70 and 72 and the seat, such as the occupant 40 of the seat.

At step 416, a determination is made as to whether
10 the distance r , determined from the distance calculation at step 414, is between low and high distance thresholds, i.e., in a distance range. In an exemplary embodiment of the present invention, the low distance threshold is twenty-five centimeters and the
15 high distance threshold is one meter. When the determination at step 416 is negative and the distance r is not between the low and high distance thresholds, i.e., is outside of the distance range, the process 400 proceeds to step 412 and an error
20 indication is provided. When the determination at step 416 is negative, it is highly probable that the view of the passenger compartment 31 from one or both of the cameras 70 and 72 of the imaging device 61 is

obstructed. When the determination at step 416 is affirmative, the process 400 proceeds to step 418.

Background information and noise are removed at step 418. Additionally, at step 418, the object that appears from processing of the images obtained by the cameras 70 and 72 is depth filled so as to remove discontinuities of the object. Such discontinuities may result from black hair or non-reflective portions of the object, such as non-reflective clothing worn by the occupant 40.

From step 418, the process 400 proceeds to step 420 and a blob algorithm is performed. The blob algorithm looks for a blob, such as that shown in Fig. 6 and designated 216, in a three-dimensional image that is formed by combining the two-dimensional images from the cameras 70 and 72. In the blob algorithm, all pixels that have an intensity value equal to or greater than a predetermined value are considered to be ON-pixels and those having an intensity value less than the predetermined value are considered to be OFF-pixels. A run/length coding is used to group all the ON-pixels together and edge detection is performed to find the edges of each blob in the image of the

viewing area. Then, the largest blob is selected for further processing.

After the blob algorithm is performed at step 420, the process 400 proceeds to step 422. At step 422, a
5 determination is made as to whether the blob has a proper size and depth. To determine whether the blob 216 has a proper size, the size of the blob 216 is compared to a predetermined blob size range. The predetermined blob size range is indicative of the
10 sizes of typical occupants of the seat. For example, blob sizes ranging from a fifth percentile female occupant to a ninety-fifth percentile male occupant may make up the predetermined blob size range. When the blob 216 falls within the predetermined blob size
15 range, the blob size is determined to be proper. When the blob size is outside of the range, the blob size is determined to be improper. The determined depth of the object is also determined from the three dimensional image of the object. To determine whether the blob 216
20 has a proper depth, the depth of the blob 216 is compared to a predetermined blob depth range. The predetermined blob depth range is indicative of the depths of typical occupants of the seat. For example, blob depths ranging from a fifth percentile female

occupant to a ninety-fifth percentile male occupant may make up the predetermined blob depth range.

When the determination at step 422 is negative and either or both of the size and depth of the blob is
5 determined to be improper, the process 400 proceeds to step 412 and an error indication is provided. When the determination at step 422 is negative, it is highly probable that the view of the passenger compartment 31 from one or both of the cameras 70 and 72 is
10 obstructed. When the determination at step 422 is affirmative, the process 400 proceeds to step 424 and the calibration of the imaging device 61 of the stereo-vision assembly 60 is checked.

Fig. 5 is a flow diagram illustrating a
15 calibration algorithm 500 in accordance with an exemplary embodiment of the present invention. The calibration algorithm 500 begins at step 502 in which a pattern recognition algorithm analyzes the images obtained by the cameras 70 and 72 for the identifying
20 marks 104. The pattern recognition algorithm may use a neural network or a support vector machine for recognizing the identifying marks 104 in the images.

At step 504, the locations of the identifying marks 104 relative to the location v (Fig. 2) of the

imaging device 61 of the stereo-vision system 60 is determined. Equation 1, above, is used to determine the distance to the identifying marks so that a three-dimensional location of each mark may be obtained. At
5 step 506, a determination is made as to whether a correction factor has previously been stored in the memory 78. When the determination at step 506 is negative, the calibration algorithm 500 proceeds to step 508. At step 508, an identifying plane that
10 contains the three identifying marks 104 is calculated. From step 508 the process proceeds to step 512.

When the determination at step 506 is affirmative and a correction factor has previously been stored, the calibration algorithm 500 proceeds to step 510. At
15 step 510, an identifying plane is calculated using the locations of the three identifying marks 104 and the correction factor. From step 510, the calibration algorithm 500 proceeds to step 512.

At step 512, the calculated identifying plane is
20 compared to the predetermined plane stored in the memory 78 and a determination is made as to whether the identifying plane and the predetermined plane are identical. When the determination at step 512 is affirmative, the imaging device 61 of the stereo-vision

assembly 60 is determined to be calibrated properly,
the calibration algorithm 500 ends, and image
processing begins so that the location of the object in
the passenger compartment 31 of the vehicle 26 is
5 determined. The image processing may use the blob
determined at step 420 to determine a location of the
occupant's head relative to the cover 32. The camera
controller 80 provides the determined location
information to the air bag controller 50 for use in
10 controlling inflation of the air bag 28.

When the determination at step 512 is negative, it
is determined that the imaging device 61 of the stereo-
vision assembly 60 is out of calibration and the
calibration algorithm 500 proceeds to step 516. At
15 step 516, a determination is made as to whether the
calculated identifying plane has shifted relative to
the predetermined plane by an amount less than a
predetermined correction threshold. When the
determination at step 516 is negative, the calibration
20 algorithm 500 ends and an error indication is provided
at step 412 of the process 400 of Fig. 4. When the
determination at step 516 is affirmative, the
calibration algorithm 500 proceeds to step 518.

At step 518, a correction factor is calculated. The correction factor is an equation representing the shift of the identifying plane from the predetermined plane. By applying the correction factor, when
5 calculating the identifying plane from the identifying marks 104, the identifying plane and the predetermined plane will be identical. Thus, the correction factor recalibrates the imaging device 61 of the stereo-vision assembly 60. At step 520, the correction factor is
10 stored in the memory 78. The calibration algorithm 500 ends after step 520 and the process 400 of Fig. 4 returns to step 406.

When the three identifying marks 104 are not visible in the image, the check of the calibration of
15 the imaging device 61 is skipped and the process 400 of Fig. 4 continues from step 422 directly to the image processing for determining the location of the object. The self-diagnostics set forth in the process 400 of Fig. 4 and the calibration algorithm 500 of Fig. 5
20 prevent the vehicle occupant protection system 20 from erroneously determining a location of an occupant 40 in response to an obstructed camera 70 or 72 or the imaging device 61 being out of calibration.

From the above description of the invention, those skilled in the art will perceive improvements, changes and modifications. For example, when a determination is made that one or both cameras 70 and 72 is blocked, the air bag controller 50 may use the previous location for the occupant 40 for a predetermined time period to control inflation of the air bag 28. After the predetermined time period, if one or both cameras 70 and 72 remains blocked, the air bag controller 50 controls inflation of the air bag 28 without any occupant location information. Such improvements, changes and modifications within the skill of the art are intended to be covered by the appended claims.